Description

Method for monitoring a vibration gyro

The invention relates to a method for monitoring a vibration gyro, which represents a resonator and is part of at least one control loop which excites the vibration gyro by supplying an excitation signal at its natural frequency, in which case an output signal can be tapped off from the vibration gyro, from which the excitation signal is derived by filtering and amplification.

By way of example, EP 0 461 761 B1 has disclosed rotation rate sensors in which a vibration gyro is stimulated on two axes which are aligned radially with respect to a main axis, for which purpose a primary and a secondary control loop are provided, with corresponding transducers, on the vibration gyro. When rotation rate sensors such as these are used in vehicles in order to stabilize the vehicle motion, dangers can occur as a result of failure or a malfunction. In order to prevent this, functional monitoring of the rotation rate sensor is required.

In the case of the method according to the invention, such monitoring is preferably carried out by measuring the Q-factor of the resonator and by producing a fault message if the Q-factor is below a threshold value.

The invention is based on the idea of the vibration gyro being arranged in an evacuated housing in order to achieve the least possible damping, and that air can enter the housing as a result of ageing or a defect, reducing or precluding the usefulness of the vibration gyro.

A first advantageous embodiment of the invention consists in that the excitation signal is switched off, and in that the

amplitude of the decaying output signal is evaluated in order to produce the fault message. This embodiment is essentially suitable for carrying out a test when the vehicle is stationary, for example in each case after switching on the ignition or during the checking of the rotation rate sensor during the course of manufacture.

This embodiment preferably provides for the fault message to be produced when the amplitude of the output signal is below a predetermined value after a predetermined time. However, the circuitry allows a number of other methods for determination of the decay time of a damped oscillation, for example counting of oscillations until they have fallen below a predetermined value.

A second embodiment of the method according to the invention consists in that an additional phase shift of the excitation signal is inserted temporarily into the control loop, and in that any frequency change caused by this is evaluated. This embodiment is fundamentally also suitable for testing during operation, in which case it depends on the individual situation whether a temporary phase shift in the excitation signal or a temporary frequency change will interfere with evaluation of the rotation rate signal for the respectively intended purpose.

One advantageous refinement of the second embodiment is particularly suitable for a digital implementation of the control loop, in that, after amplification and analog/digital conversion, the output signal is demodulated to an in-phase component and a quadrature component, in that the quadrature component modulates a carrier, after filtering, which carrier is supplied as an excitation signal to the vibration gyro, in that the in-phase component is supplied, after filtering, to a PLL circuit, which controls the frequency and the phase of the carrier, in that a signal which corresponds to the frequency change is supplied to the PLL circuit in order to shift the

phase of the excitation signal, and causes a phase change in the carrier.

The second embodiment of the method according to the invention can preferably be refined in such a way that the phase shift is approximately 10° with respect to the carrier.

The invention allows numerous exemplary embodiments. One of these is illustrated schematically in the drawing with reference to a number of figures, and will be described in the following text. In the figures:

Figure 1 shows a block diagram of a rotation rate sensor,

Figure 2 shows timing diagrams of signals which occur in a first exemplary embodiment,

Figure 3 shows timing diagrams of signals in a second exemplary embodiment,

Figure 4 shows a block diagram of a rotation rate sensor which is designed to carry out a method according to the first embodiment, and

Figure 5 shows a block diagram of a rotation rate sensor which is designed to carry out a method according to the second embodiment.

The exemplary embodiments as well as parts of them are admittedly illustrated in the form of block diagrams. However, this does not mean that the arrangement according to the invention is restricted to an implementation with the aid of individual circuits corresponding to the blocks. The arrangement according to the invention can in fact be implemented in a particularly advantageous manner with the aid of large-scale-integrated circuits. In this case,

microprocessors can be used which, when suitably programmed, carry out the processing steps illustrated in the block diagrams.

Figure 1 shows a block diagram of an arrangement having a vibration gyro 1 with two inputs 2, 3 for a primary excitation signal PD and a secondary excitation signal SD. Suitable transducers, for example electromagnetic transducers, are used for excitation purposes. The vibration gyro also has two outputs 4, 5 for a primary output signal PO and a secondary output signal SO. These signals reflect the respective vibration at spatially offset points on the gyro. Gyros such as these are known, for example, from EP 0 307 321 A1 and are based on the Coriolis force effect.

The vibration gyro 1 represents a high Q-factor filter, with the path between the input 2 and the output 4 being part of a primary control loop 6, and the path between the input 3 and the output 5 being part of a secondary control loop 7. The primary control loop 6 is used for excitation of oscillations at the resonant frequency of the vibration gyro of, for example, 14 kHz. The excitation in this case is applied on one axis of the vibration gyro, with the oscillation direction that is used for the secondary control loop being offset through 90° with respect to this. The signal SO is split in the secondary control loop 7 into two components, one of which is passed via a filter 8 to an output 9, from which a signal which is proportional to the rotation rate can be tapped off.

A major proportion of the signal processing is carried out in digital form in both control loops 6, 7. The clock signals which are required for signal processing are produced in a crystal-controlled digital frequency synthesizer 10, whose clock frequency in the illustrated example is 14.5 MHz. The application of the method according to the invention is based primarily on the use of the primary control loop for which reason Figures 4 and 5 illustrate exemplary embodiments of the primary control loop.

In the exemplary embodiment explained with reference to Figure 2, the control loop is interrupted at the time T1 by a switching signal that is illustrated in Figure 2a, in response to which the output signal PO (Figure 2b) carries out a damped oscillation. A suitable measurement signal records when the amplitude of the output signal PO no longer reaches a predetermined threshold. This time is compared with a threshold value, which is not illustrated. If the time is relatively long, the vibration gyro also has sufficiently low damping. However, if it is too heavily damped, this time threshold value is not reached, and an appropriate fault message is emitted.

In the second exemplary embodiment, a switching signal that is shown in Figure 3a introduces an additional phase shift between the times t1 and t2. In order to maintain the resonance conditions, the control loop reacts by a change in the frequency fPO, as is illustrated in Figure 3b. In this case, if the frequency change exceeds a threshold value S, the Q-factor of the vibration gyro is sufficiently high. If, in contrast, the frequency change is less, then there is high damping, so that a fault message is triggered.

The primary control loop which is illustrated in Figures 4 and 5 has an amplifier 11 for the output signal PO, to which an antialiasing filter 12 and an analog/digital converter 13 are connected. Splitting into an in-phase component and a quadrature component is carried out with the aid of multipliers 14, 15, to which carriers Ti1 and Tq1 are supplied. Both components then pass through a respective (sinx/x) filter 16, 17 and a low-pass filter 18, 19. The filtered real part is supplied to a PID regulator 20, which controls the digital frequency synthesizer, as a result of which a phase control circuit is closed, which produces the correct phase angle for the carriers Ti1 and Tq1. Furthermore, a carrier Tq2 is produced and is modulated in a circuit 22 with the output signal from a further PID regulator 21, which receives the

low-pass-filtered imaginary part. The output signal from the circuit 22 is supplied to the input 2 of the vibration gyro 1 as the excitation signal PD.

A microcomputer 23 controls, in addition to other processes, the measures which are required to carry out the method according to the invention. In the case of the exemplary embodiment shown in Figure 4, it produces the switching signal that is illustrated in Figure 2a and passes this to the circuit 22, thus interrupting the excitation signal PD. A circuit 24 for measurement of the amplitude, for example an amplitude demodulator, is connected to the output of the analog/digital converter 13. The output of the circuit 24 is connected to a threshold value circuit 25, whose output signal is supplied to the microcomputer 23. The transient time and thus the Q-factor of the vibration generator can thus be determined in the microcomputer 23.

In the exemplary embodiment shown in Figure 5, the microcomputer 23 passes a signal corresponding to that in Figure 3a to the frequency synthesizer, which produces an additional phase shift. The reaction of the phase locked loop comprises the frequency synthesizer selecting a different division from the clock frequency in order to change the frequency of the carriers. This can be supplied as a measure of the frequency discrepancy to the microcomputer 23, which then carries out the evaluation process as explained in conjunction with Figure 3.